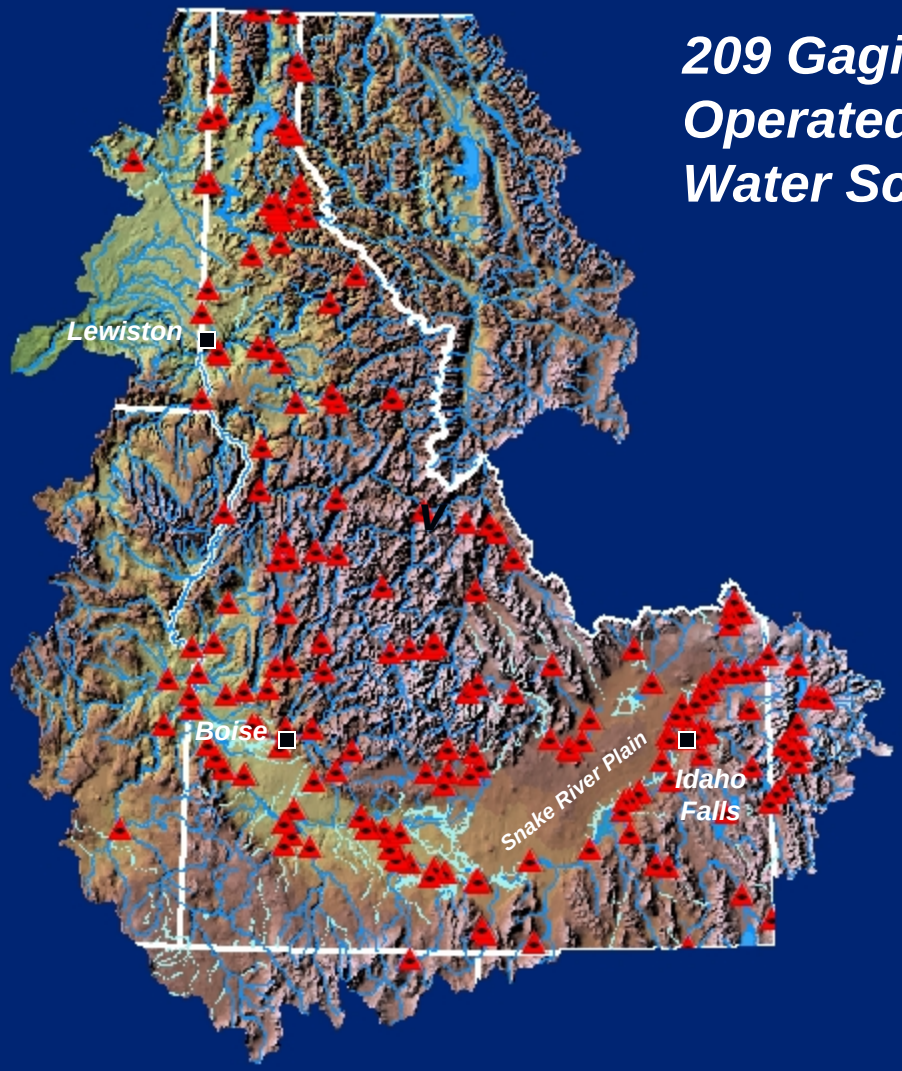
Changes in Historical Patterns of Streamflow from Unregulated Watersheds in Idaho

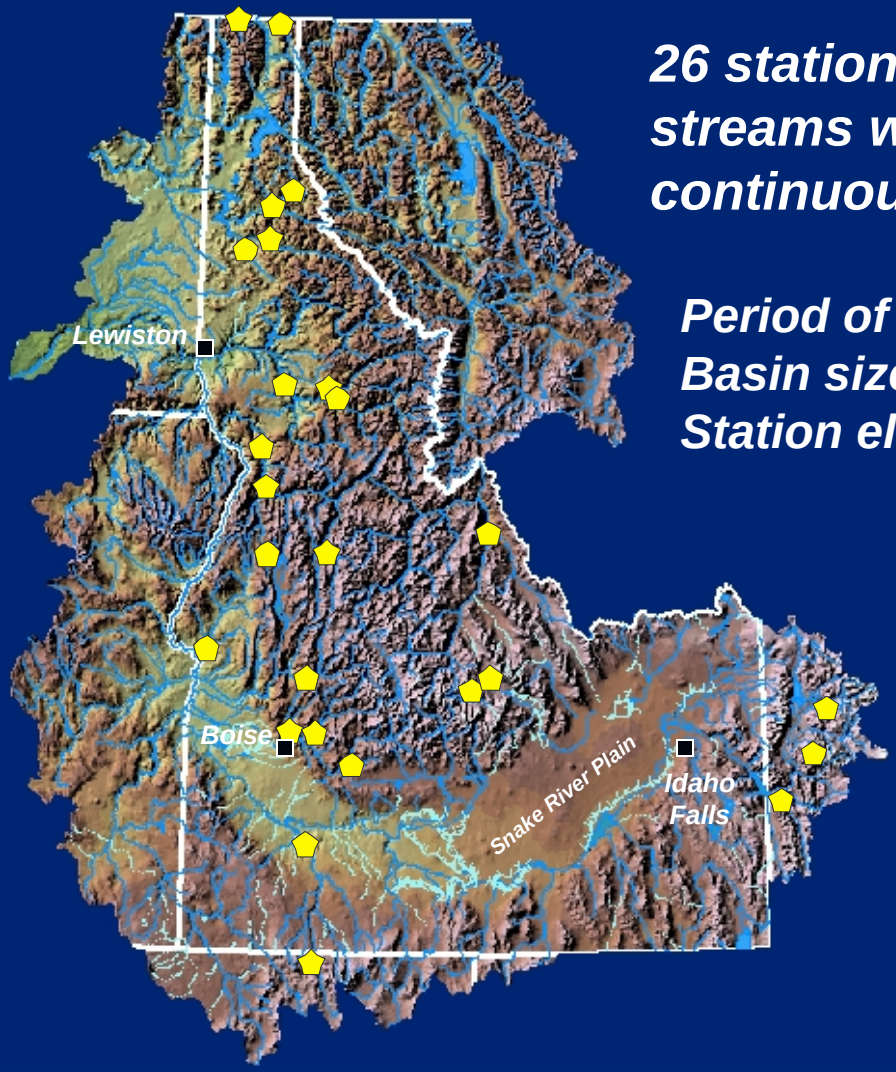
Greg Clark
USGS-WRD
Boise, ID

USGS
science for a changing world



209 Gaging Stations Currently Operated by the USGS - Idaho Water Science Center

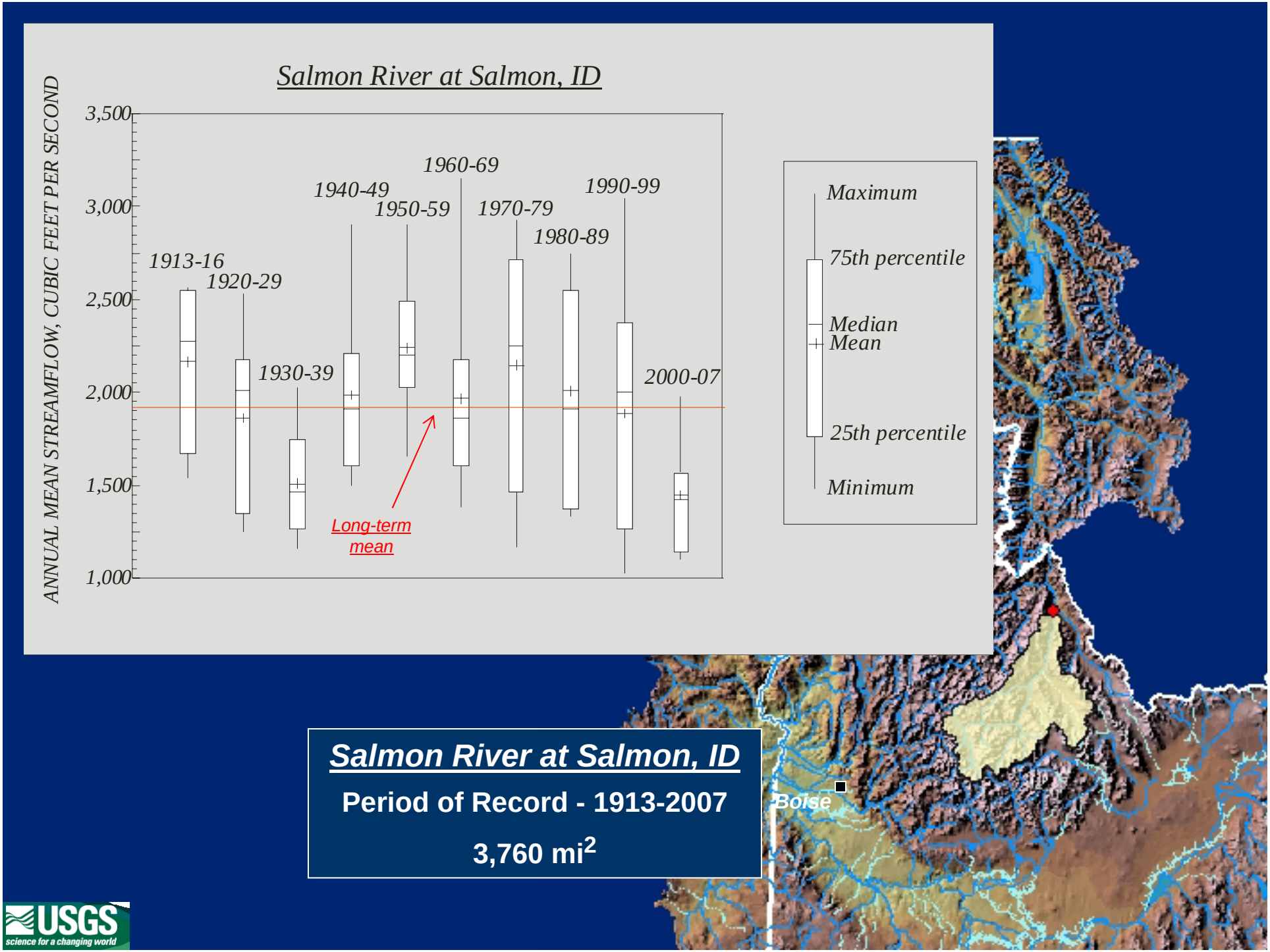
USGS
science for a changing world

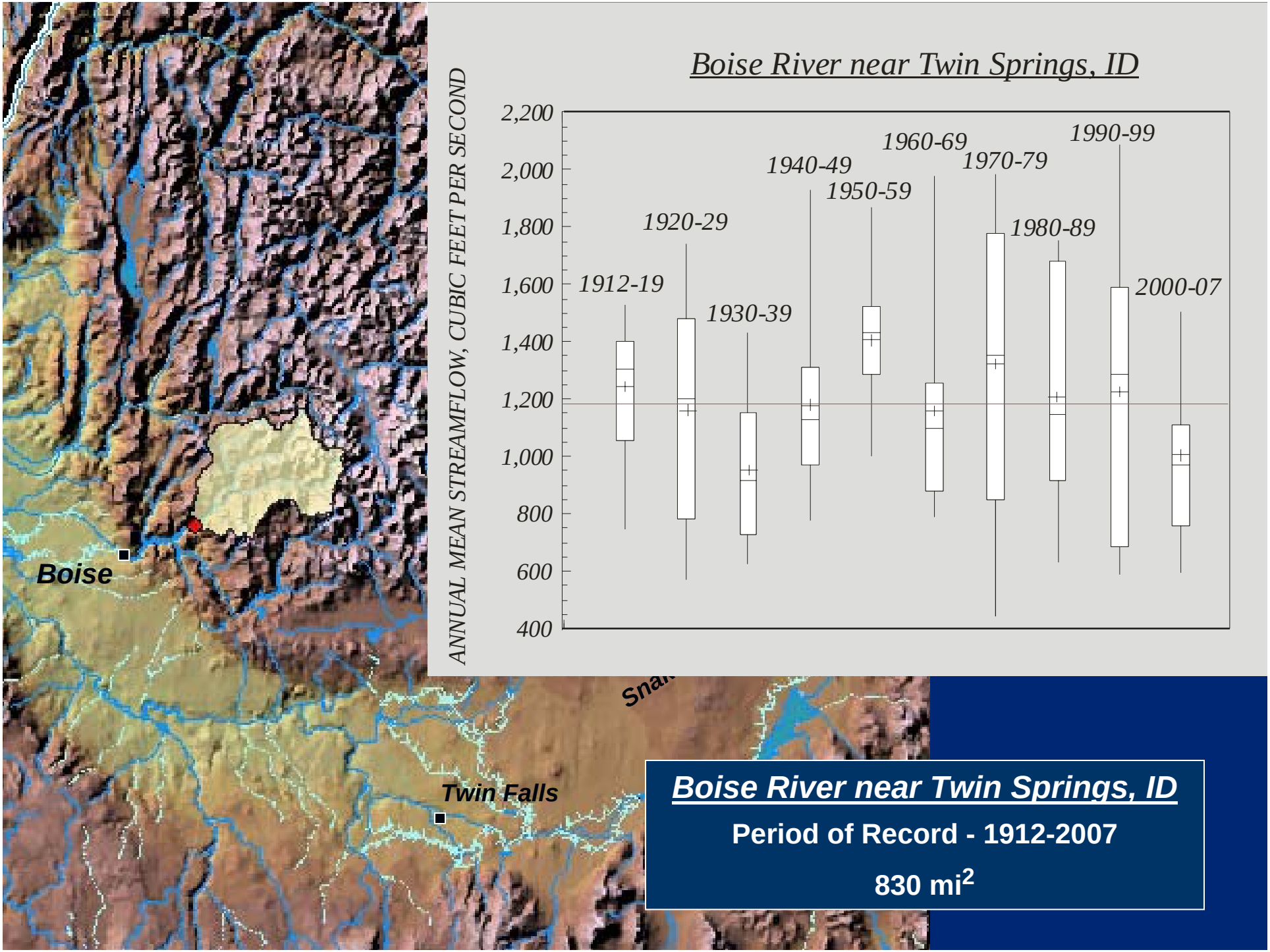


26 stations located on unregulated streams with at least 40 years of continuous stream discharge

Period of record; 41 – 96 years
Basin size; 11 – 13,550 mi^2
Station elevation; 1,770 – 6,820 ft

USGS
science for a changing world


Salmon River at Salmon, ID
ANNUAL MEAN STREAMFLOW, CUBIC FEET PER SECOND
3,500
3,000
2,500
2,000
1,500
1,000
1913-16
1920-29
1930-39
1940-49
1950-59
1960-69
1970-79
1980-89
1990-99
2000-07
Long-term mean
Maximum
75th percentile
Median
Mean
25th percentile
Minimum
Boise
Salmon River at Salmon, ID
Period of Record - 1913-2007
3,760 mi2
USGS
science for a changing world


Boise River near Twin Springs, ID
ANNUAL MEAN STREAMFLOW, CUBIC FEET PER SECOND
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
1912-19
1920-29
1930-39
1940-49
1950-59
1960-69
1970-79
1980-89
1990-99
2000-07
Boise
Twin Falls
Boise River near Twin Springs, ID
Period of Record - 1912-2007
830 mi2

Trends in the annual mean stream discharge

USGS
science for a changing world

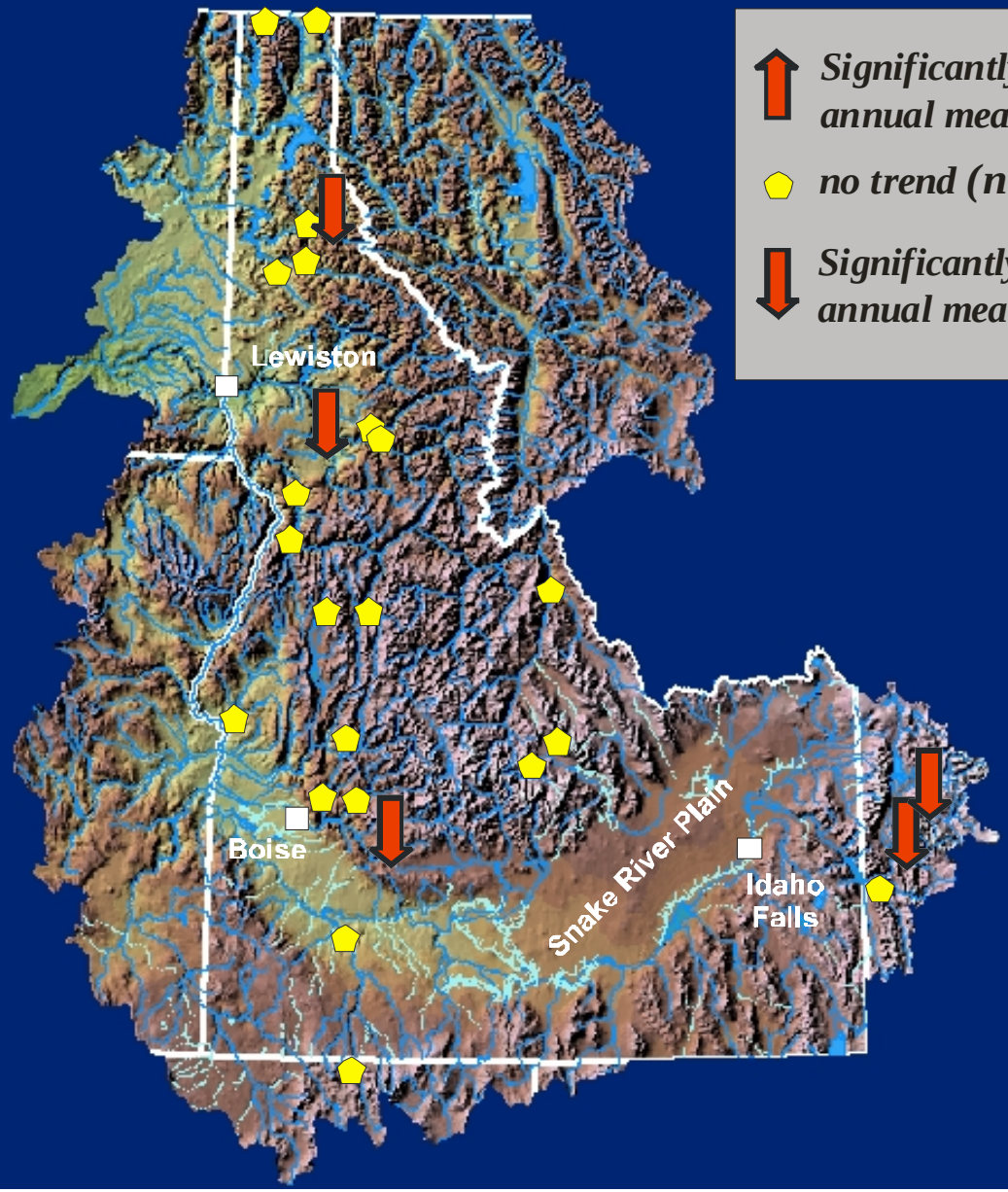
Nonparametric Mann – Kendall test for trend

Provides a direction of trend, slope with time, and p-value of significance.

- Runoff parameters evaluated
  - Annual *mean* stream discharge
  - Annual *peak* stream discharge
  - Annual *minimum* stream discharge
  - Date of the *midpoint* of annual total stream discharge
  - Date of the *first quartile* of annual total stream discharge

USGS science for a changing world

Trends in annual *mean* stream discharge *(p<0.10)*



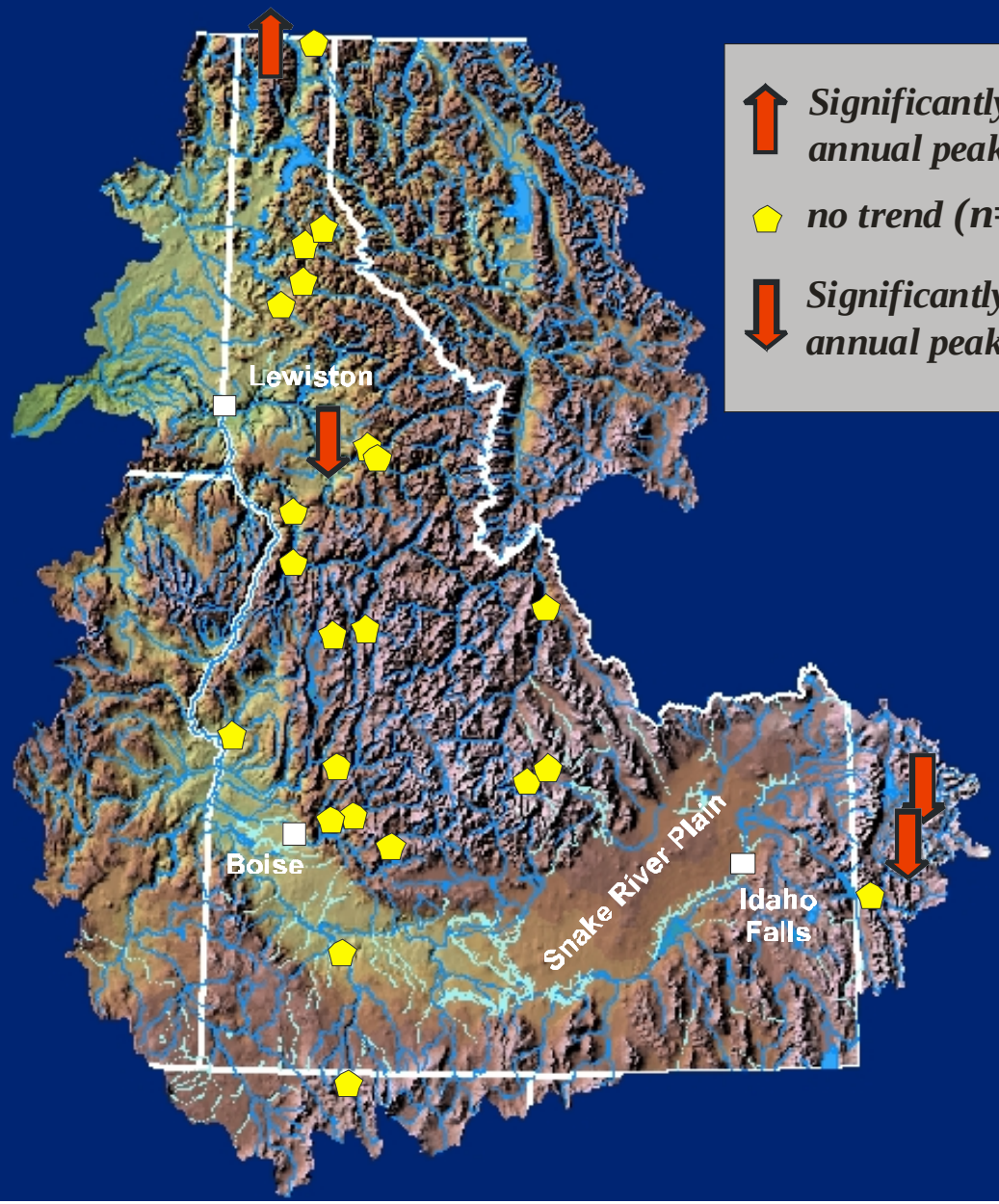
Significantly larger annual mean (n=0)

no trend (n=21)

Significantly smaller annual mean (n=5)

USGS science for a changing world

Trends in annual *peak* stream *discharge* *(p<0.10)*



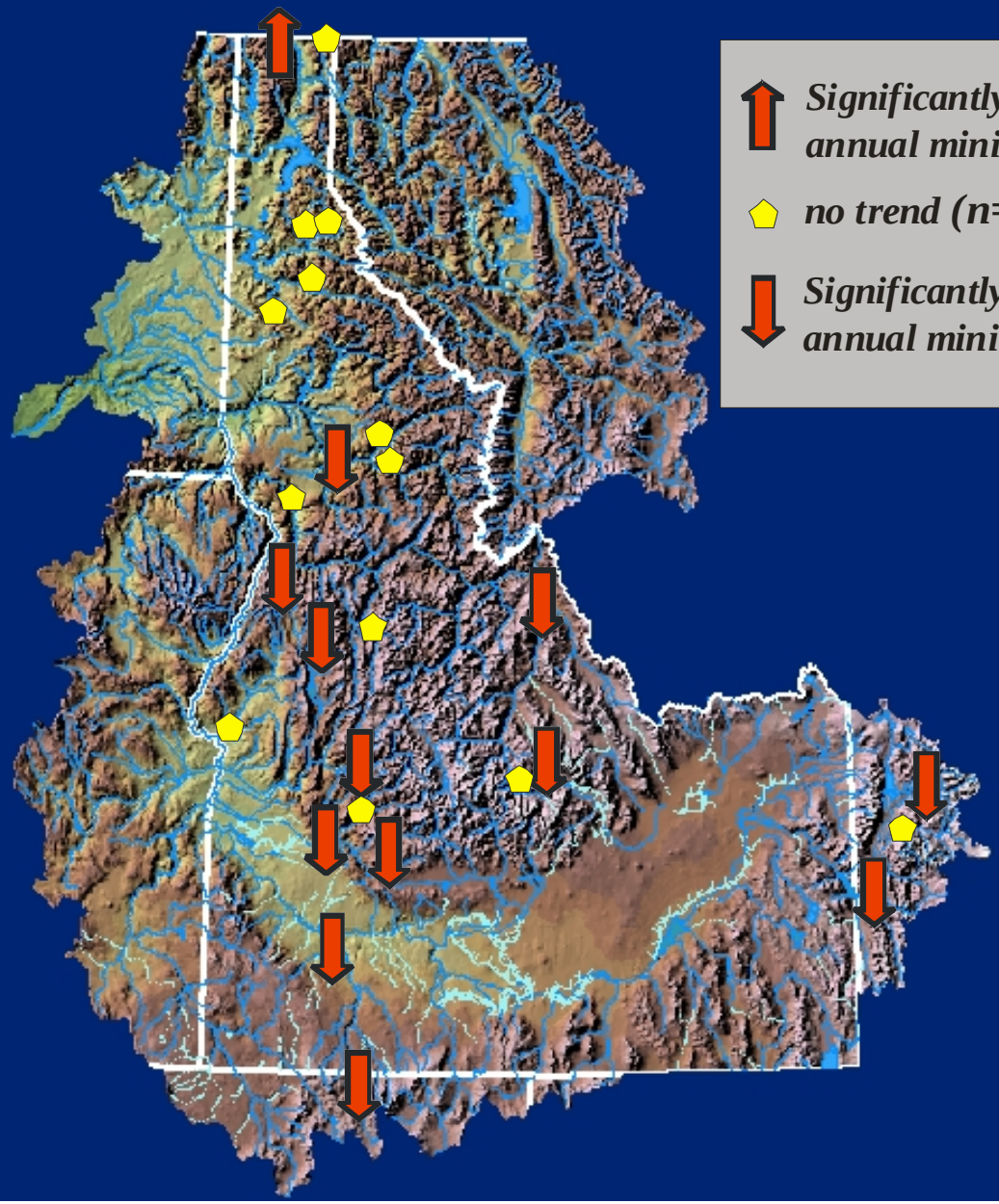
Significantly larger annual peak (n=1)

no trend (n=22)

Significantly smaller annual peak (n=3)

USGS science for a changing world

Trends in annual *minimum* stream discharge *(p<0.10)*



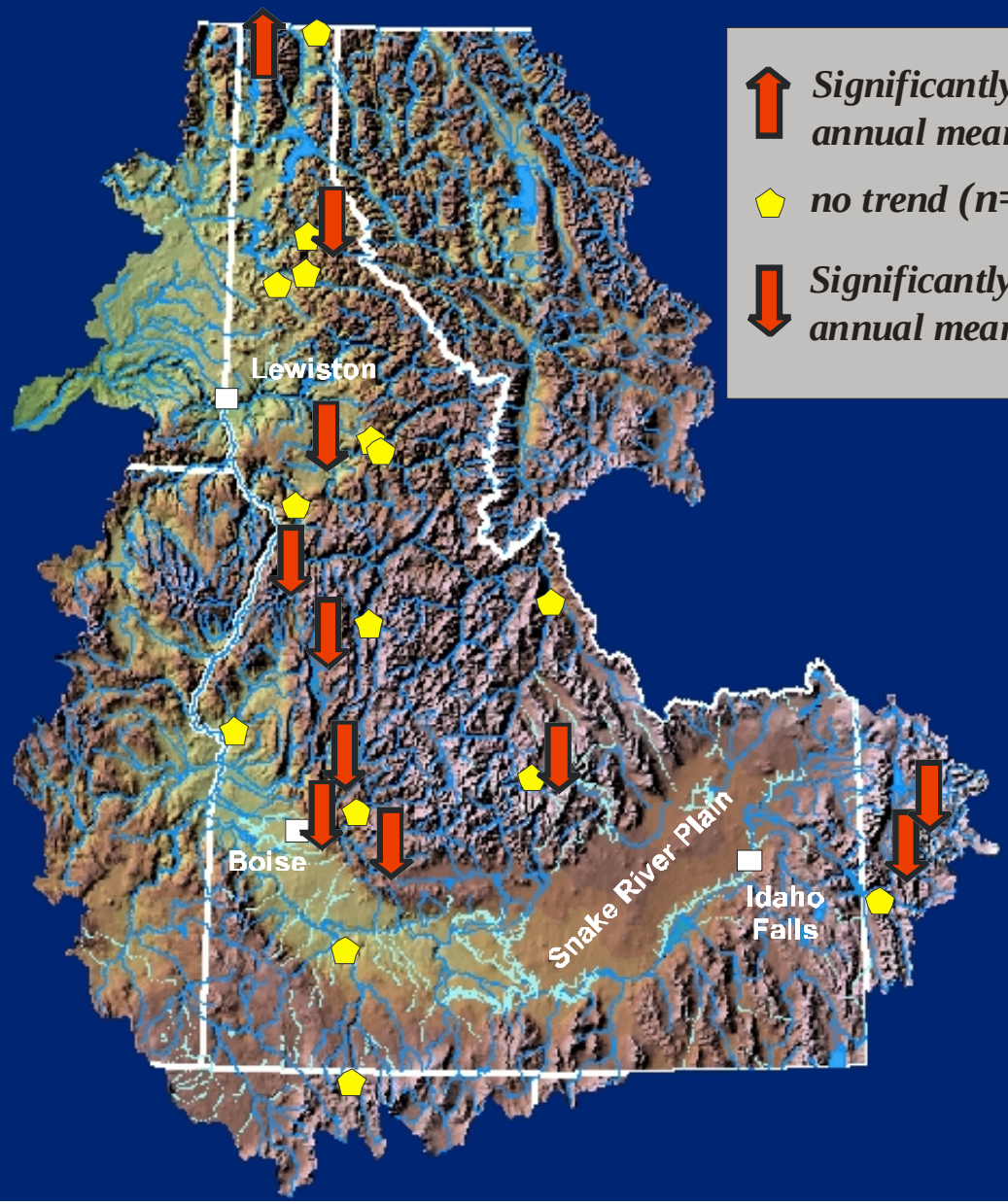
Significantly larger annual minimum (n=1)

no trend (n=13)

Significantly smaller annual minimum (n=12)

USGS science for a changing world

Trends in annual *mean* stream discharge *(p<0.30)*



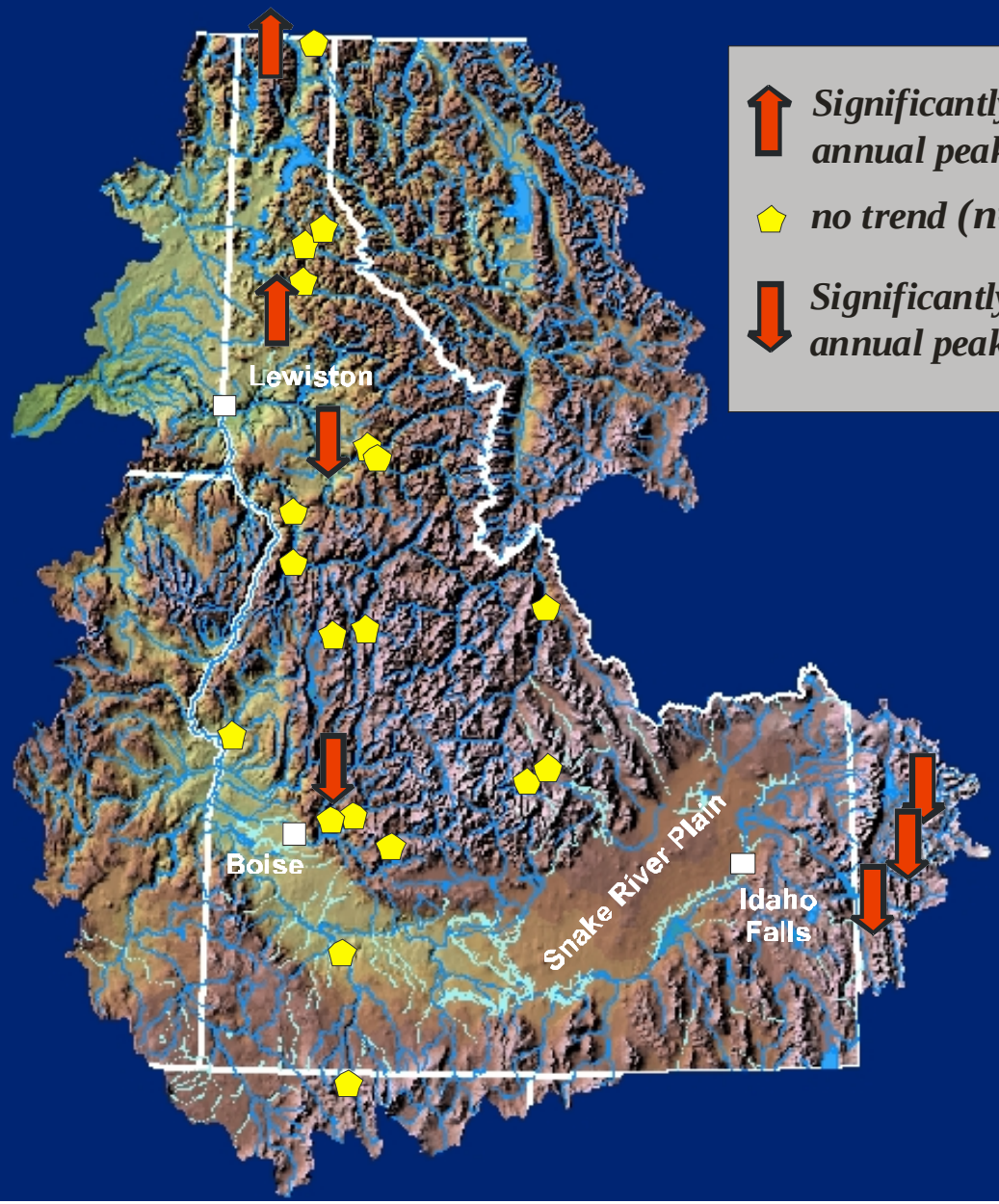
Significantly larger annual mean (n=1)

no trend (n=15)

Significantly smaller annual mean (n=10)

USGS science for a changing world

Trends in annual *peak* stream discharge *(p<0.30)*



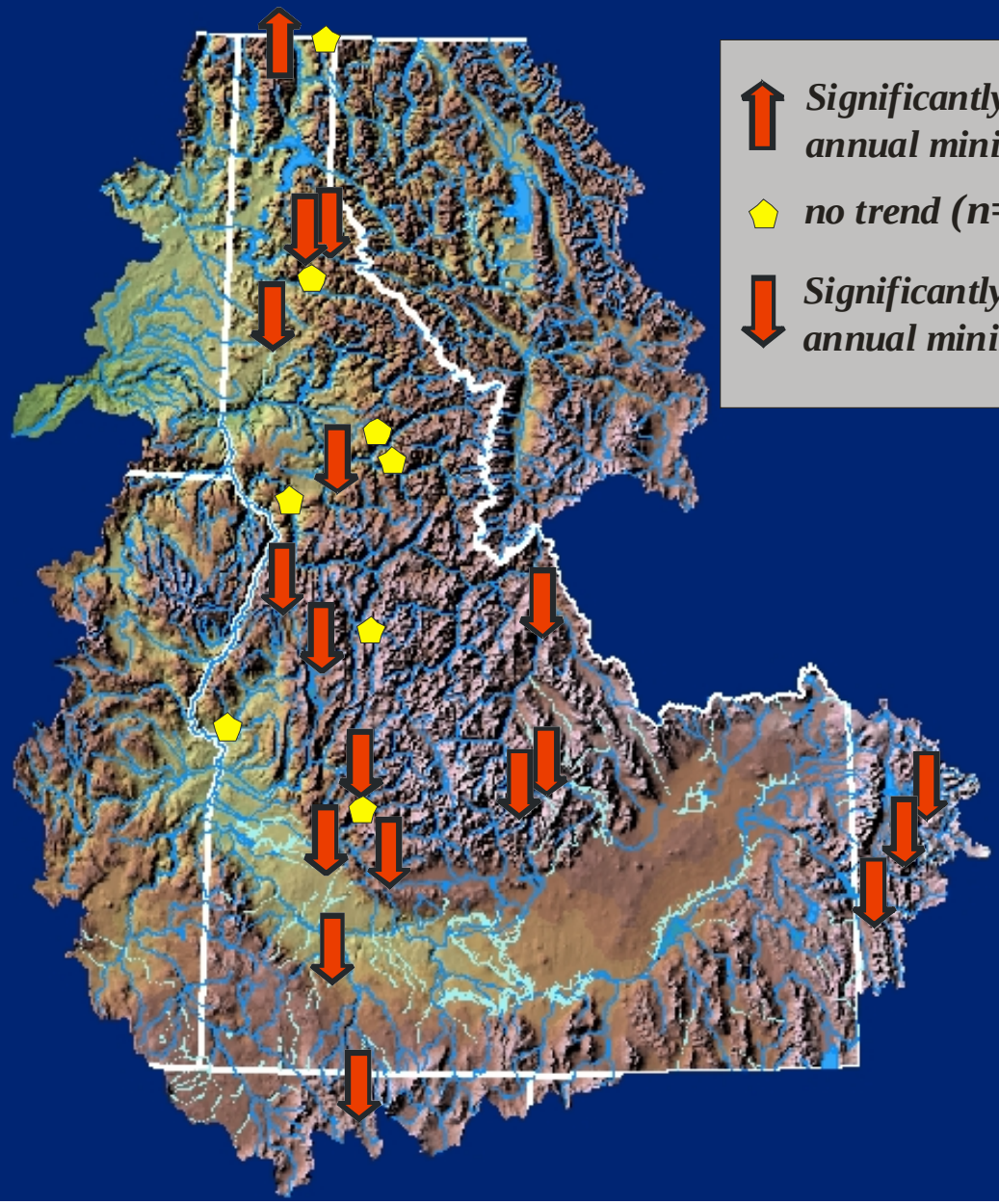
Significantly larger annual peak (n=2)

no trend (n=19)

Significantly smaller annual peak (n=5)

USGS science for a changing world

Trends in annual *minimum* stream discharge *(p<0.30)*

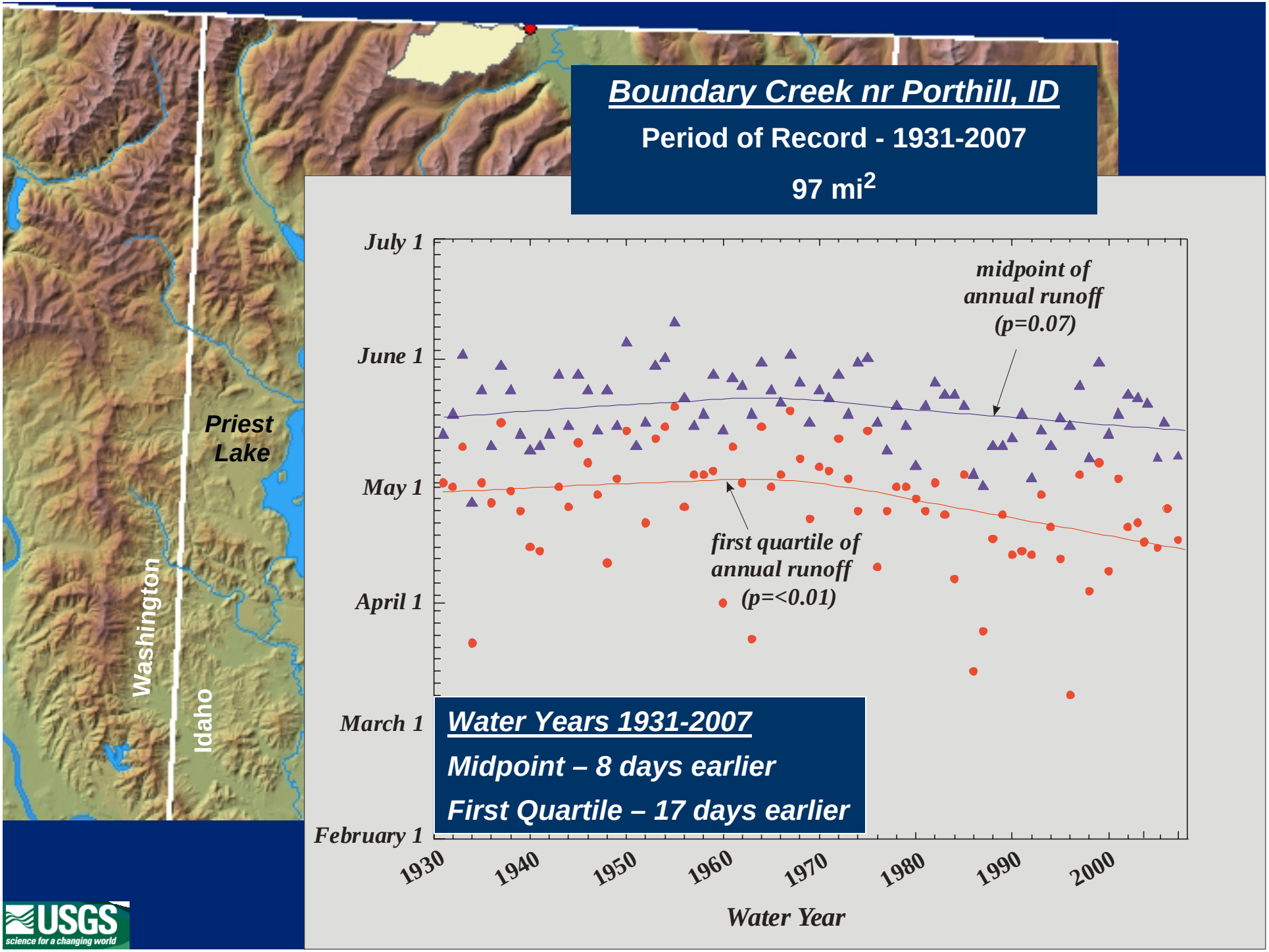


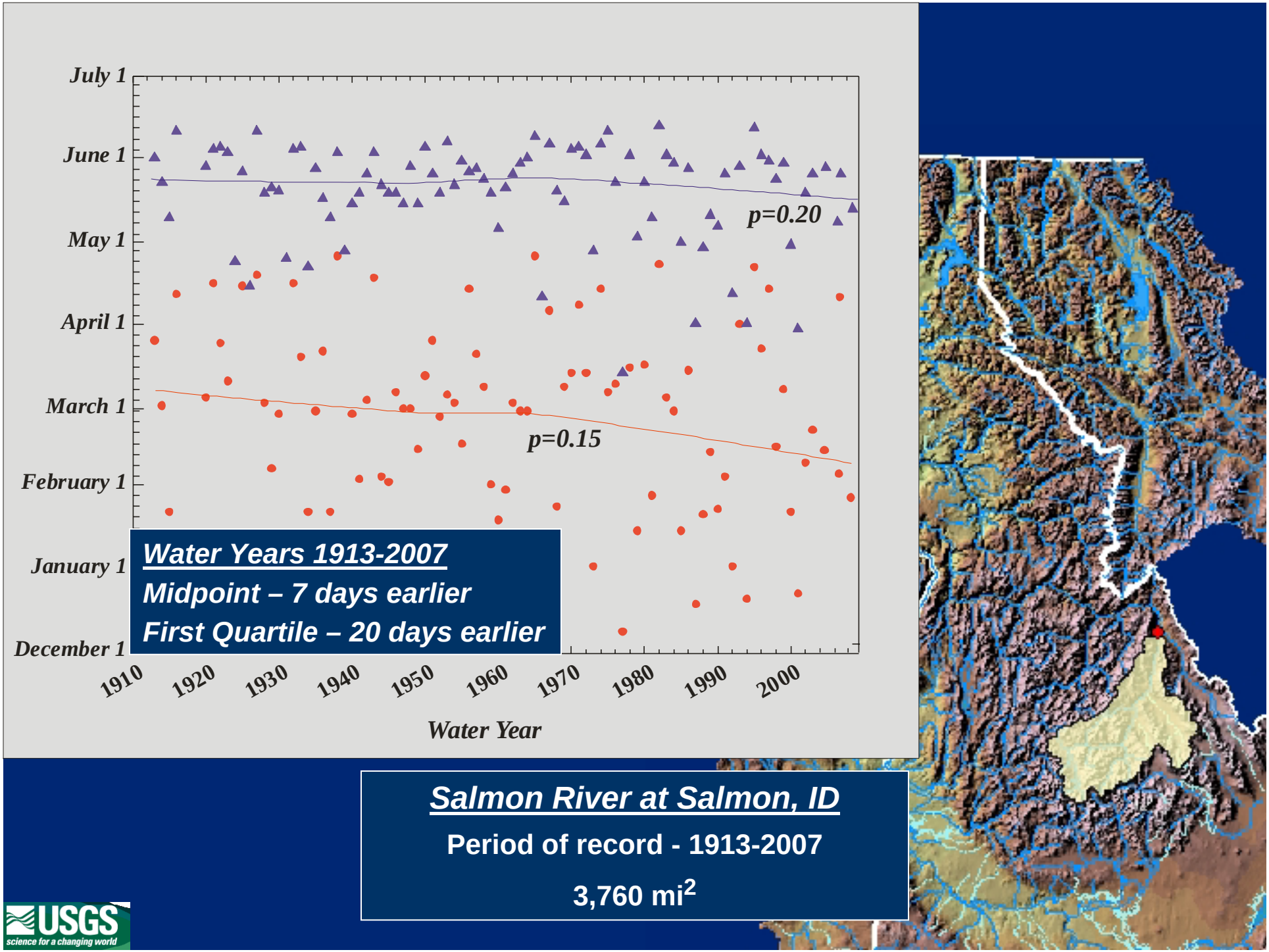
Significantly larger annual minimum (n=1)

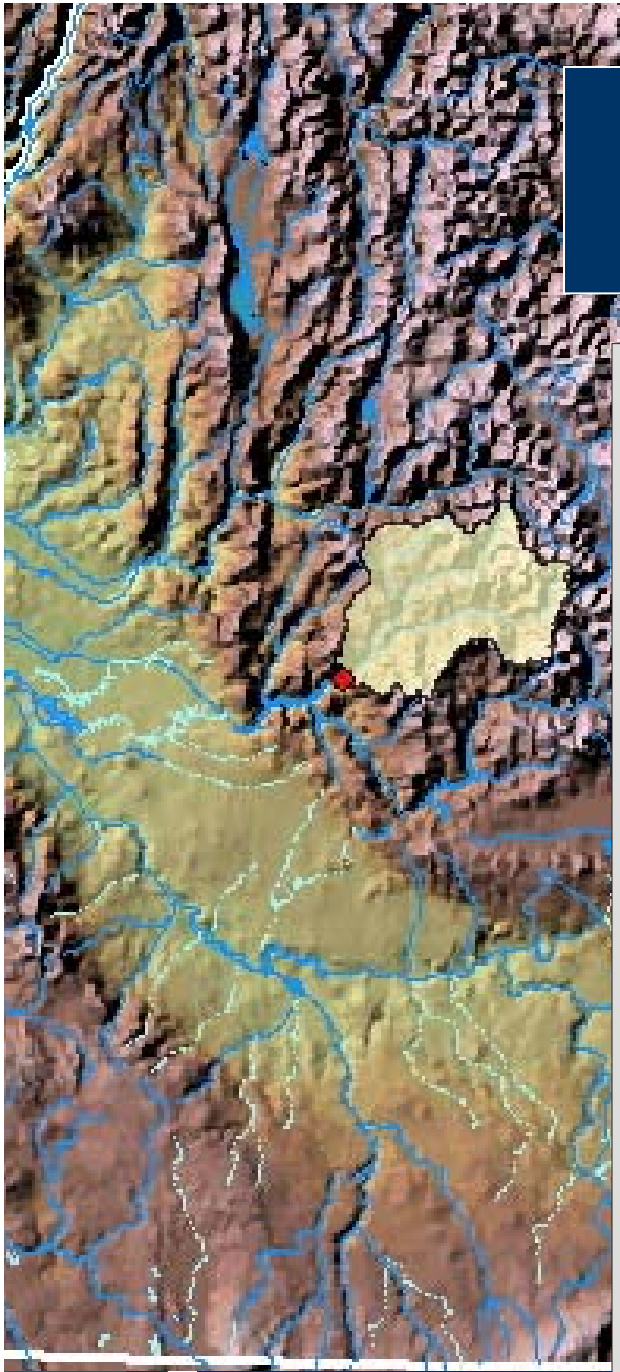
no trend (n=8)

Significantly smaller annual minimum (n=17)

USGS science for a changing world


Boundary Creek nr Porthill, ID
Period of Record - 1931-2007
97 mi2
July 1
June 1
May 1
April 1
March 1
February 1
midpoint of annual runoff (p=0.07)
first quartile of annual runoff (p=<0.01)
Water Years 1931-2007
Midpoint – 8 days earlier
First Quartile – 17 days earlier
1930
1940
1950
1960
1970
1980
1990
2000
Water Year
Priest Lake
Washington
Idaho
USGS
science for a changing world

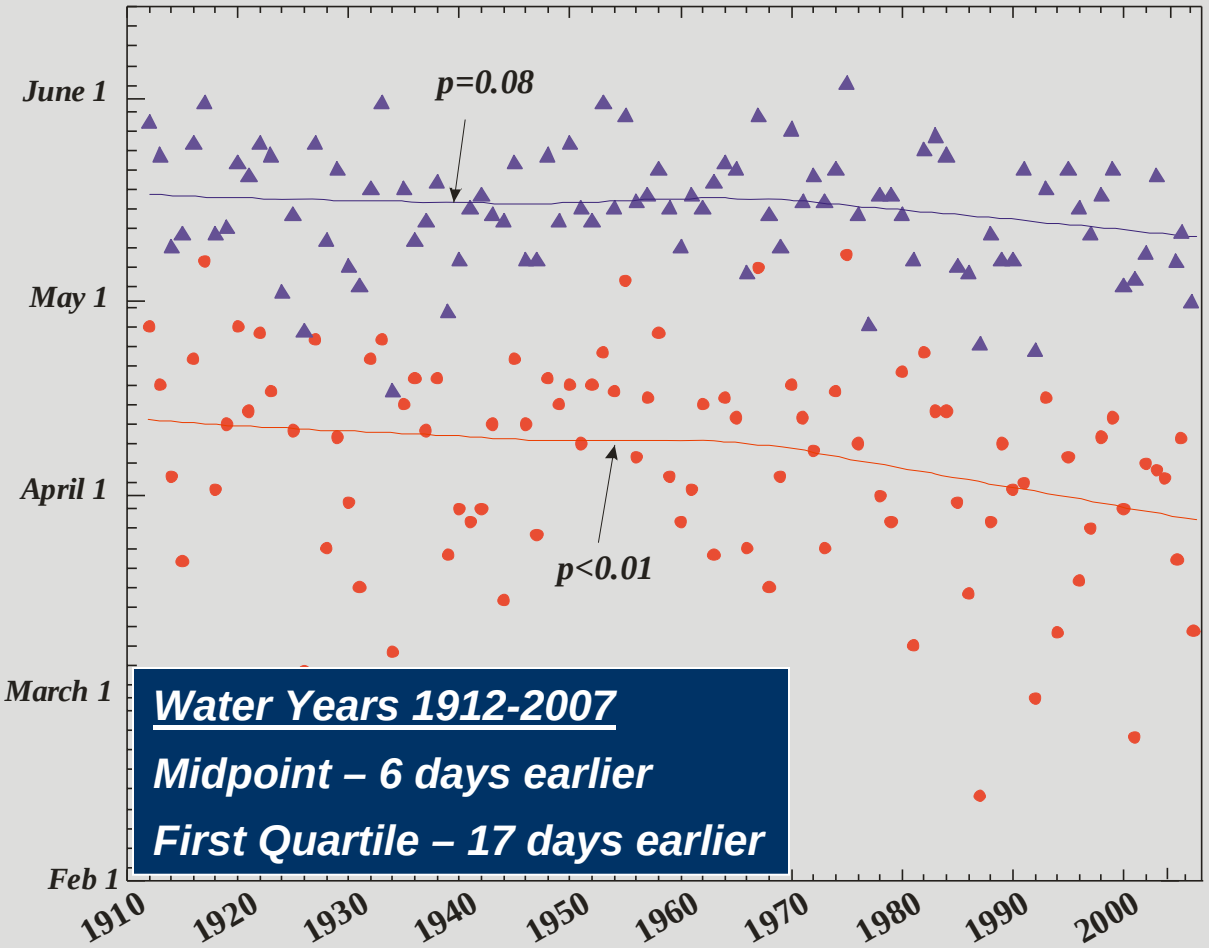

July 1
June 1
May 1
April 1
March 1
February 1
January 1
December 1
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Water Year
p=0.20
p=0.15
Water Years 1913-2007
Midpoint – 7 days earlier
First Quartile – 20 days earlier
Salmon River at Salmon, ID
Period of record - 1913-2007
3,760 mi2
USGS
science for a changing world



Boise River near Twin Springs, ID

Period of Record - 1912-2007

830 mi^2



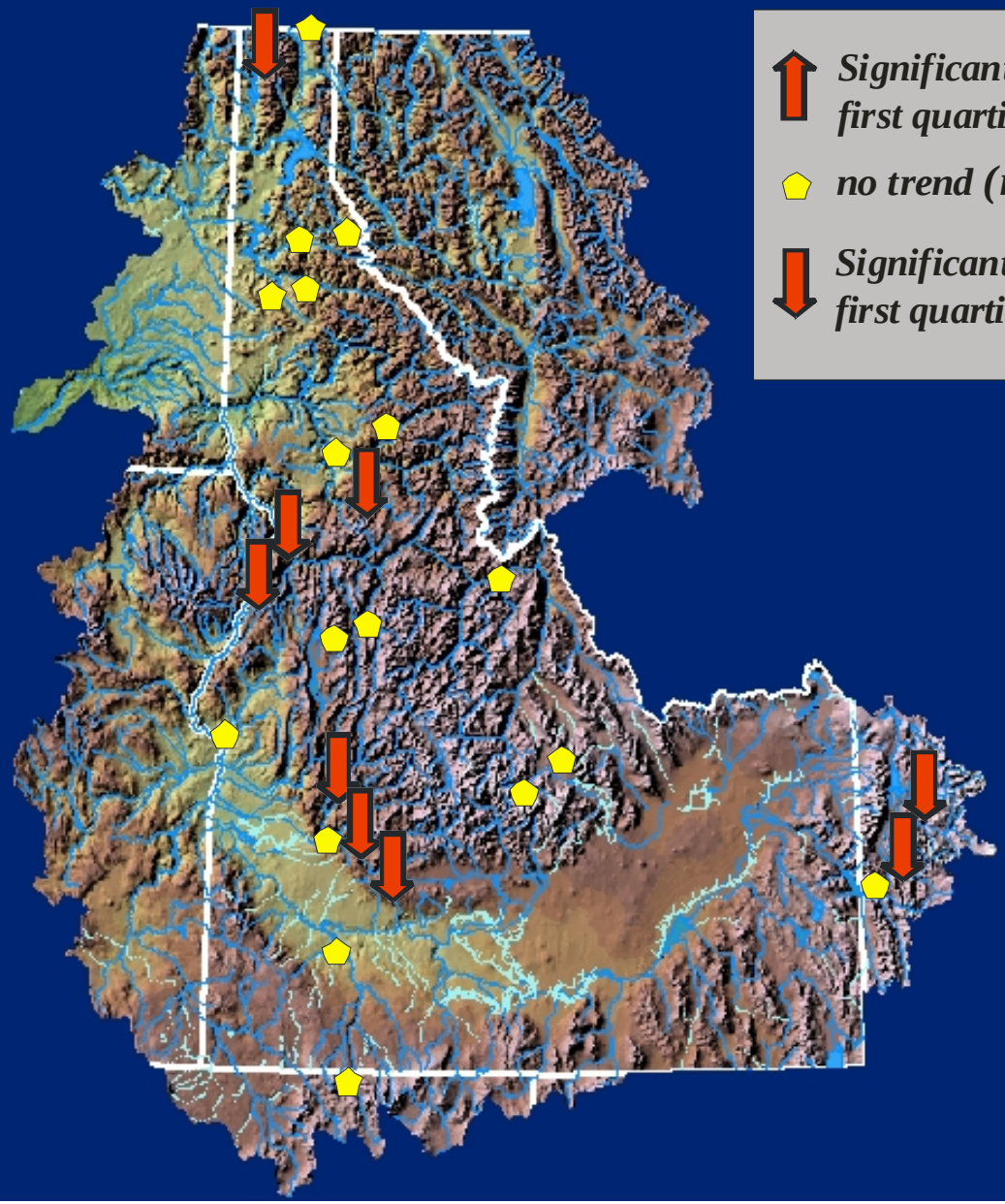
Water Years 1912-2007

Midpoint – 6 days earlier

First Quartile – 17 days earlier

USGS science for a changing world

Trends in timing of first quartile of stream discharge *(p<0.10)*



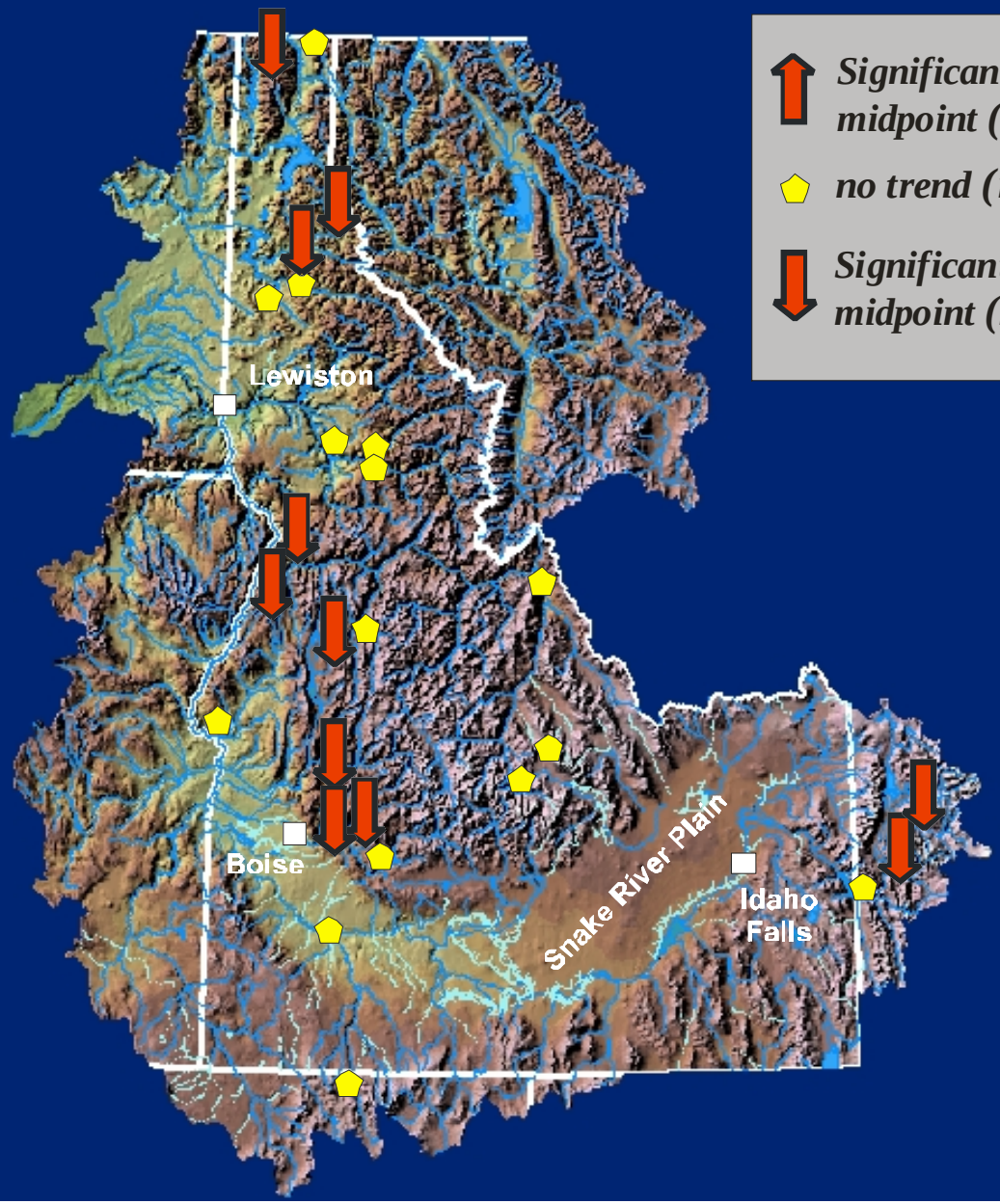
Significantly later first quartile (n=0)

no trend (n=17)

Significantly earlier first quartile (n=9)

USGS science for a changing world

Trends in timing of midpoint of stream discharge *(p<0.10)*



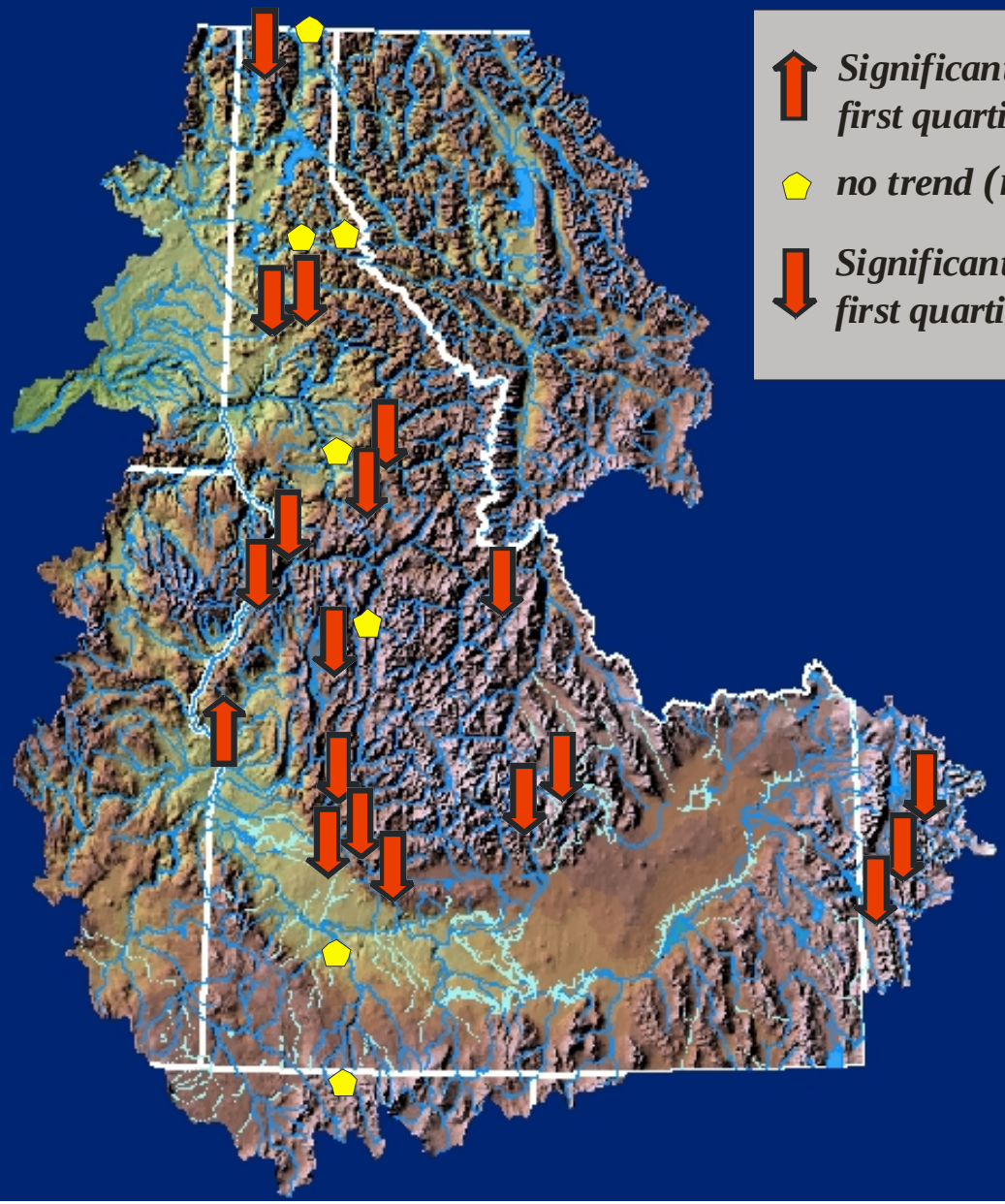
Significantly later midpoint (n=0)

no trend (n=15)

Significantly earlier midpoint (n=11)

USGS science for a changing world

Trends in timing of first quartile of stream discharge *(p<0.30)*



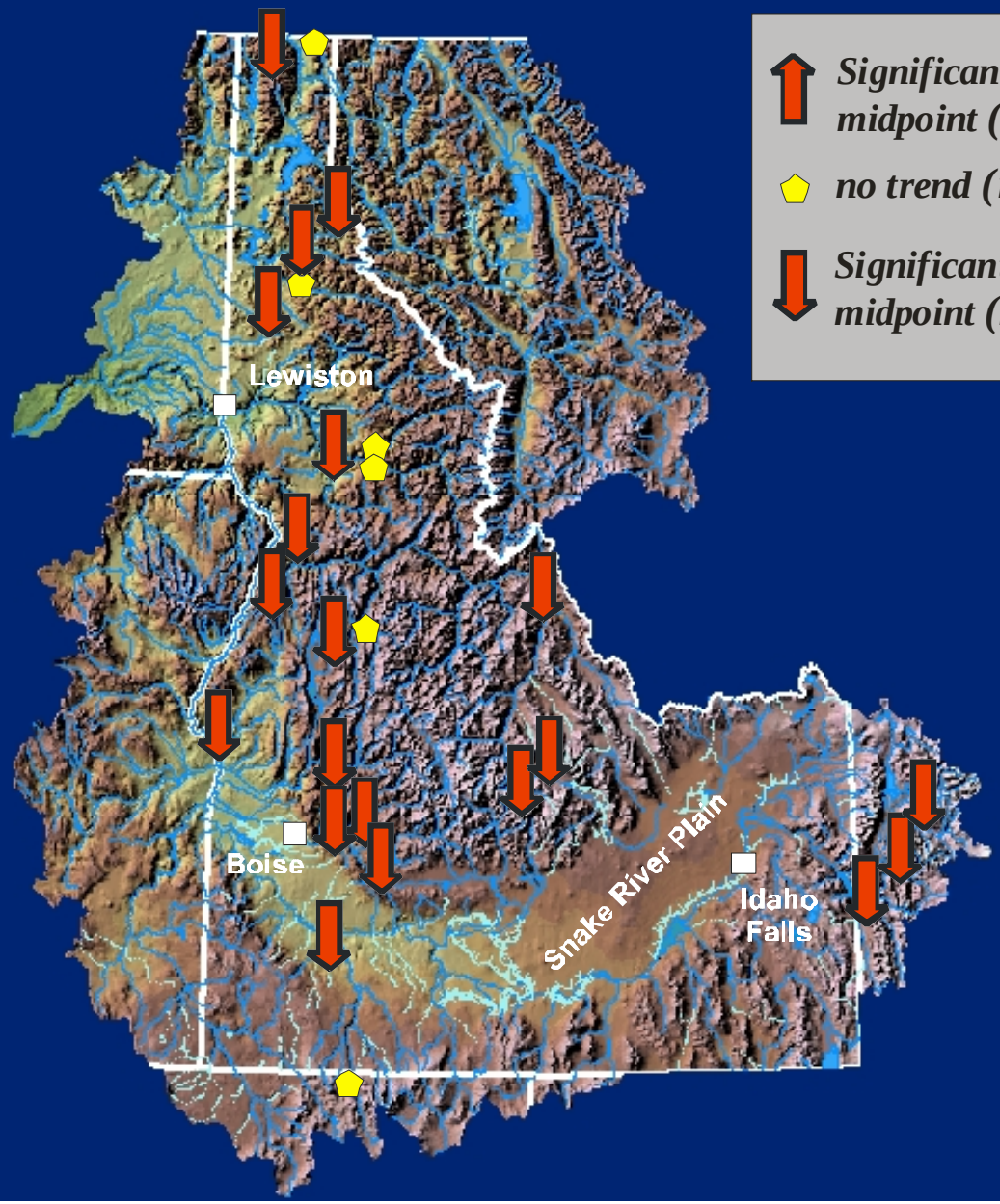
Significantly later first quartile (n=1)

no trend (n=7)

Significantly earlier first quartile (n=18)

USGS science for a changing world

Trends in timing of midpoint of stream discharge *(p<0.30)*

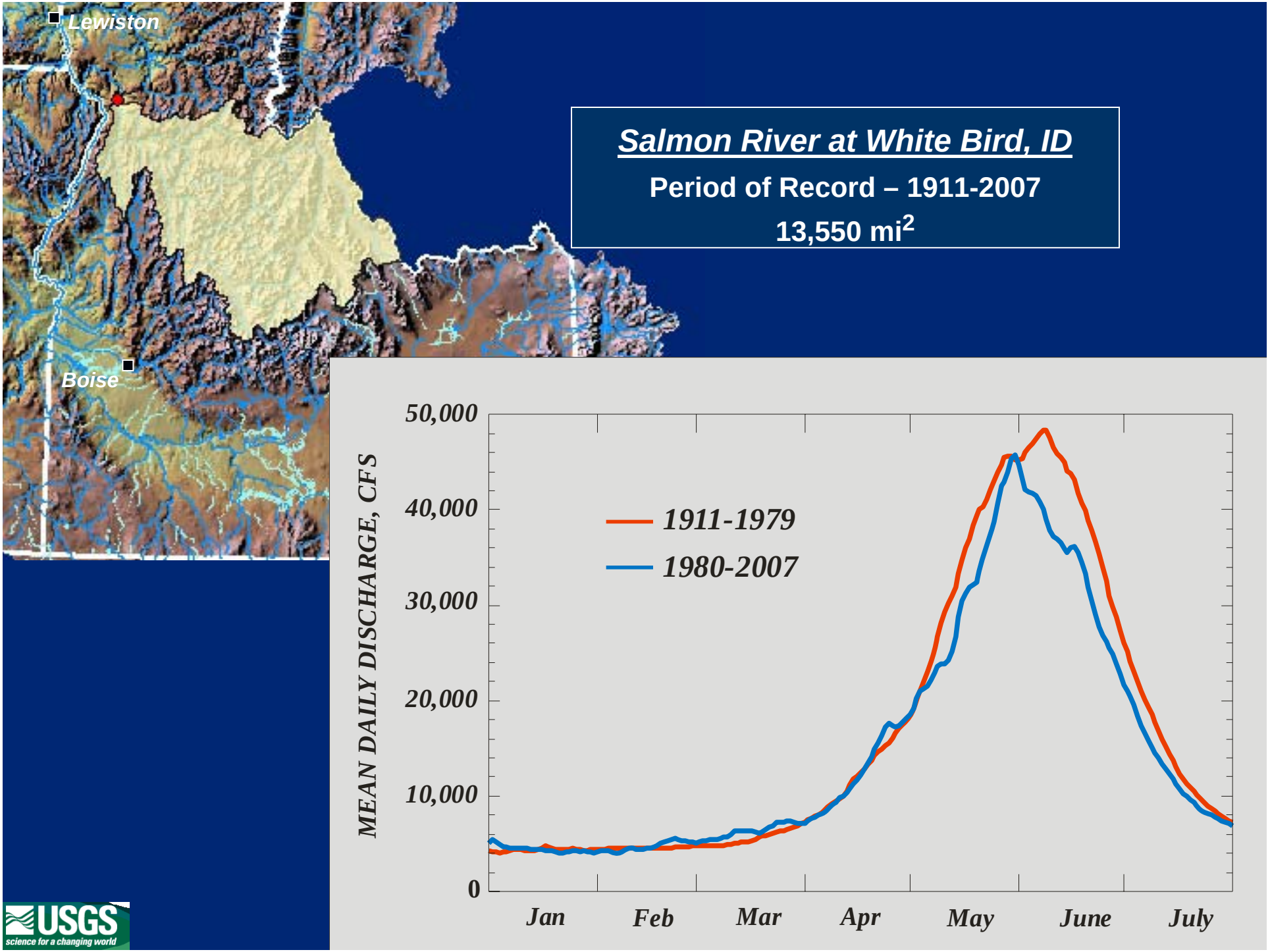


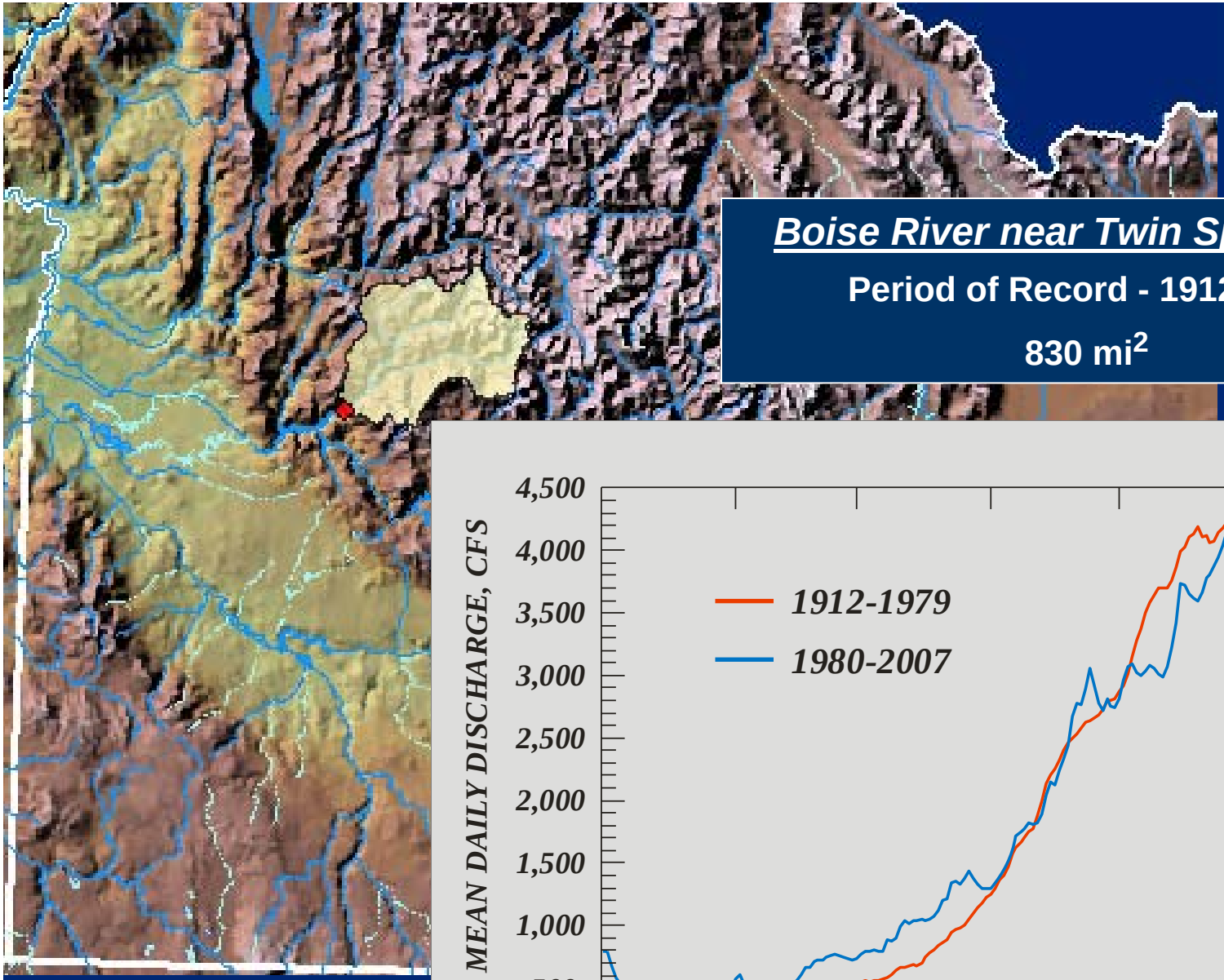
Significantly later midpoint (n=0)

no trend (n=6)

Significantly earlier midpoint (n=20)

USGS science for a changing world

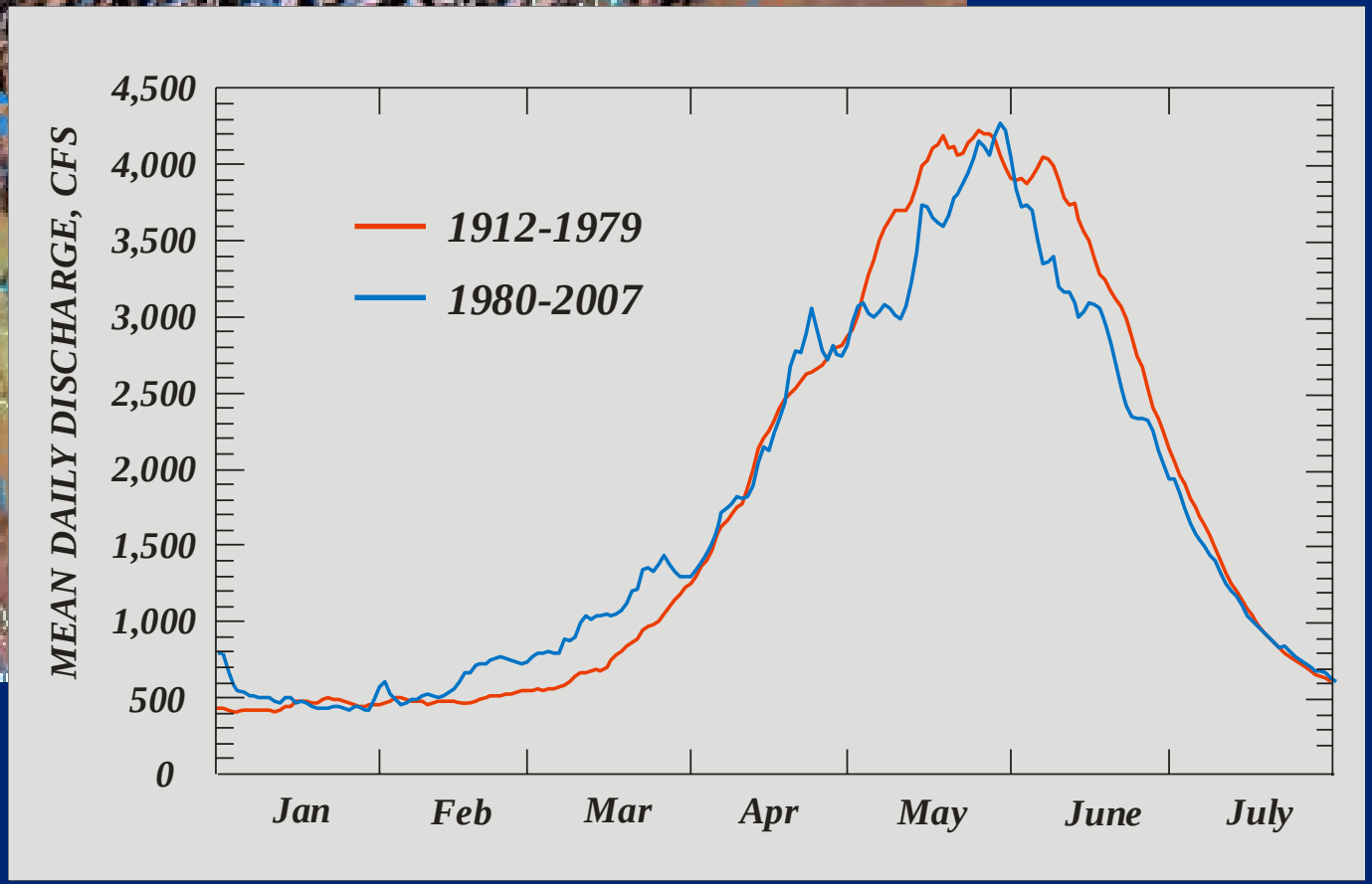

Lewiston
Boise
Salmon River at White Bird, ID
Period of Record – 1911-2007
13,550 mi2
MEAN DAILY DISCHARGE, CFS
50,000
40,000
30,000
20,000
10,000
0
1911-1979
1980-2007
Jan
Feb
Mar
Apr
May
June
July
USGS
science for a changing world



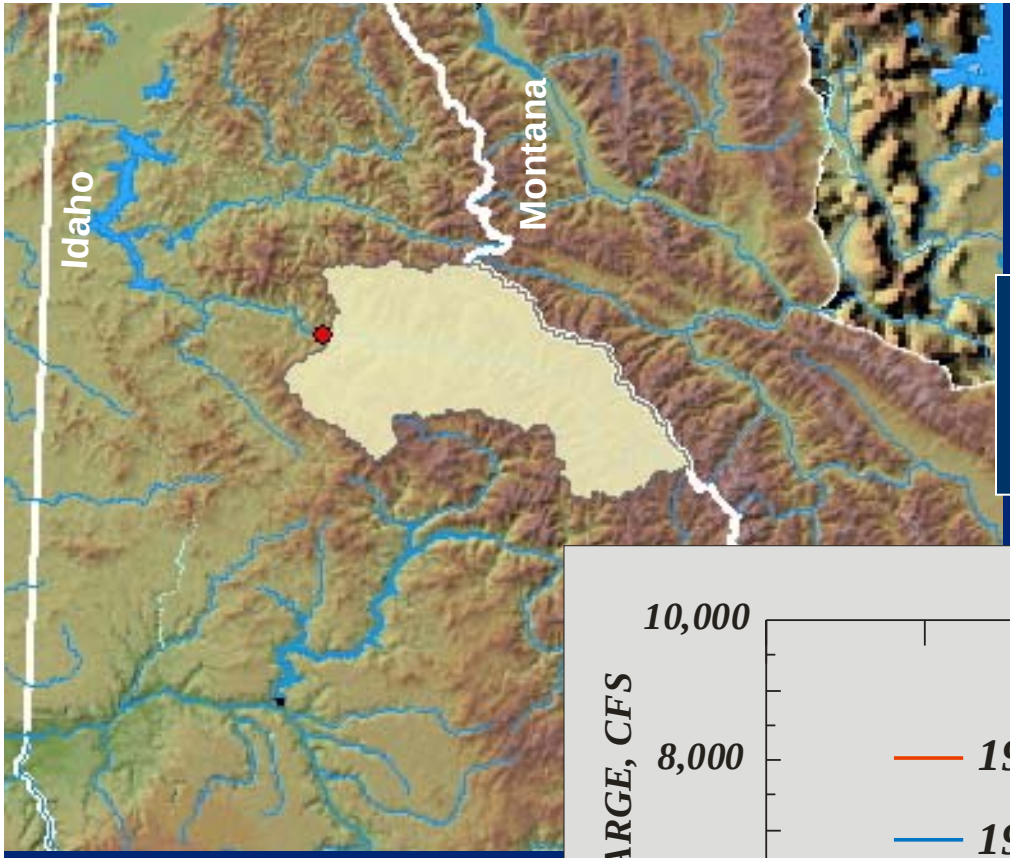
Boise River near Twin Springs, ID

Period of Record - 1912-2007

830 mi^2



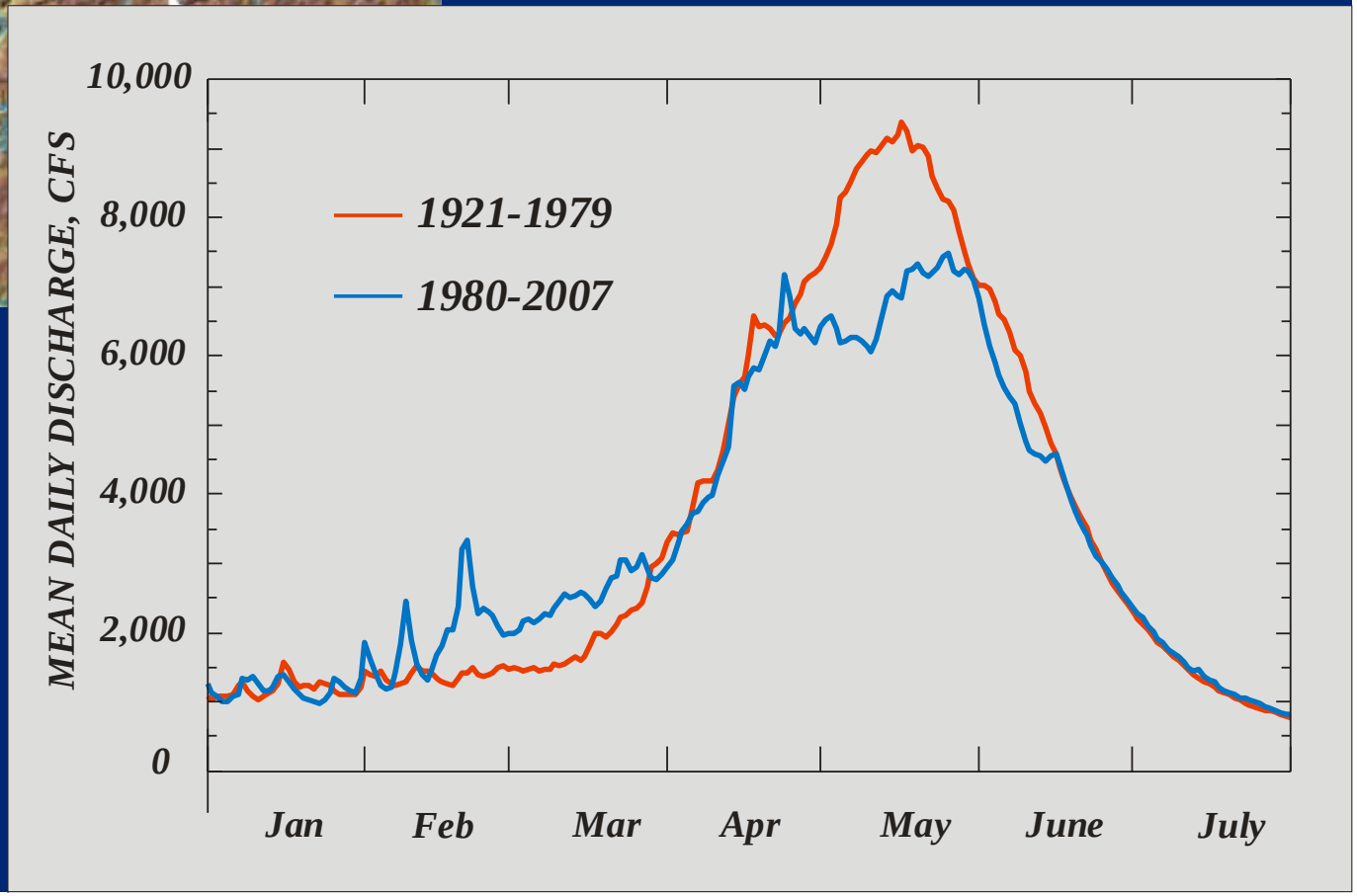
USGS
science for a changing world



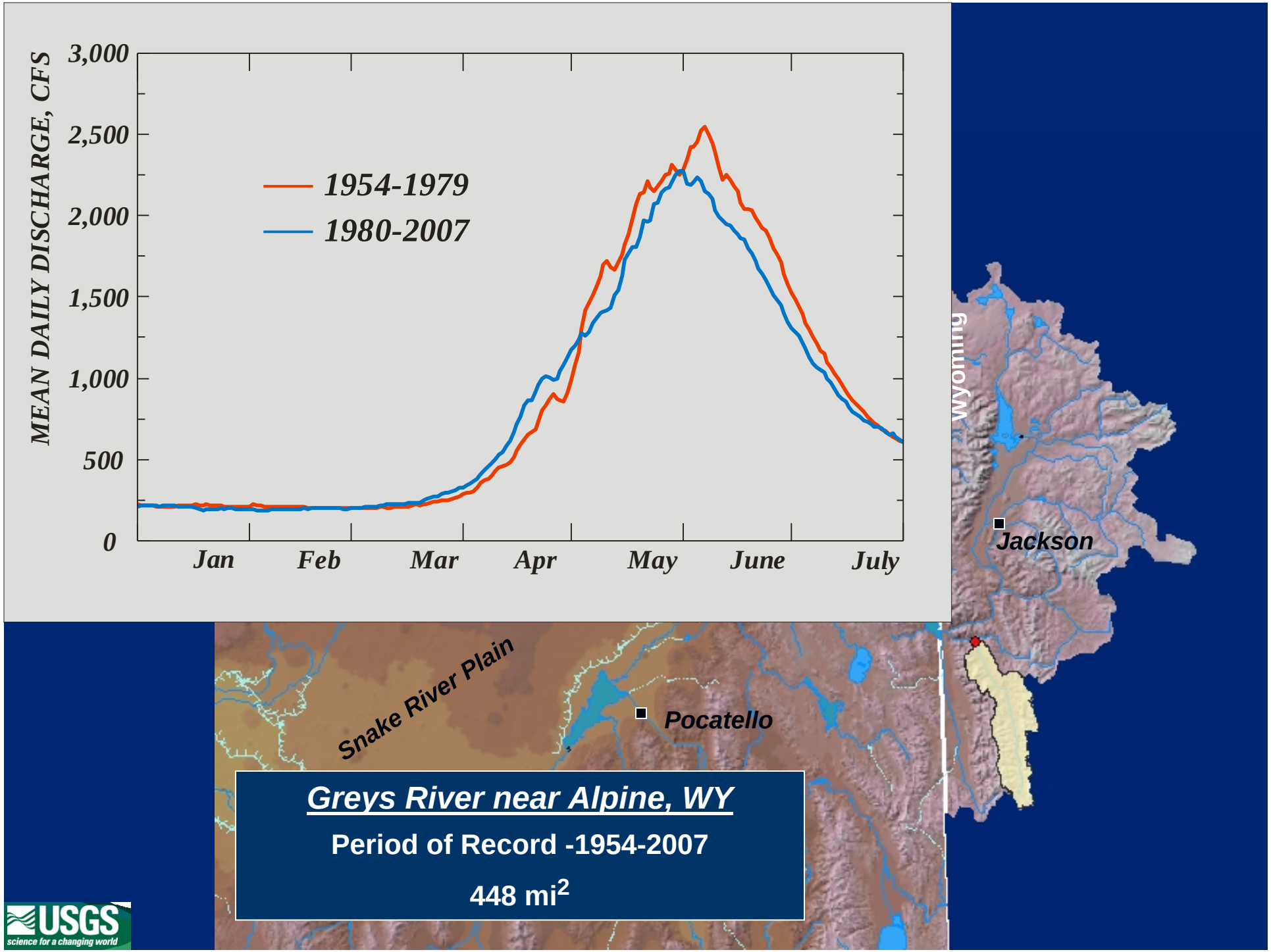
St. Joe River at Calder, ID

Period of Record - 1921-2007

1,030 mi^2

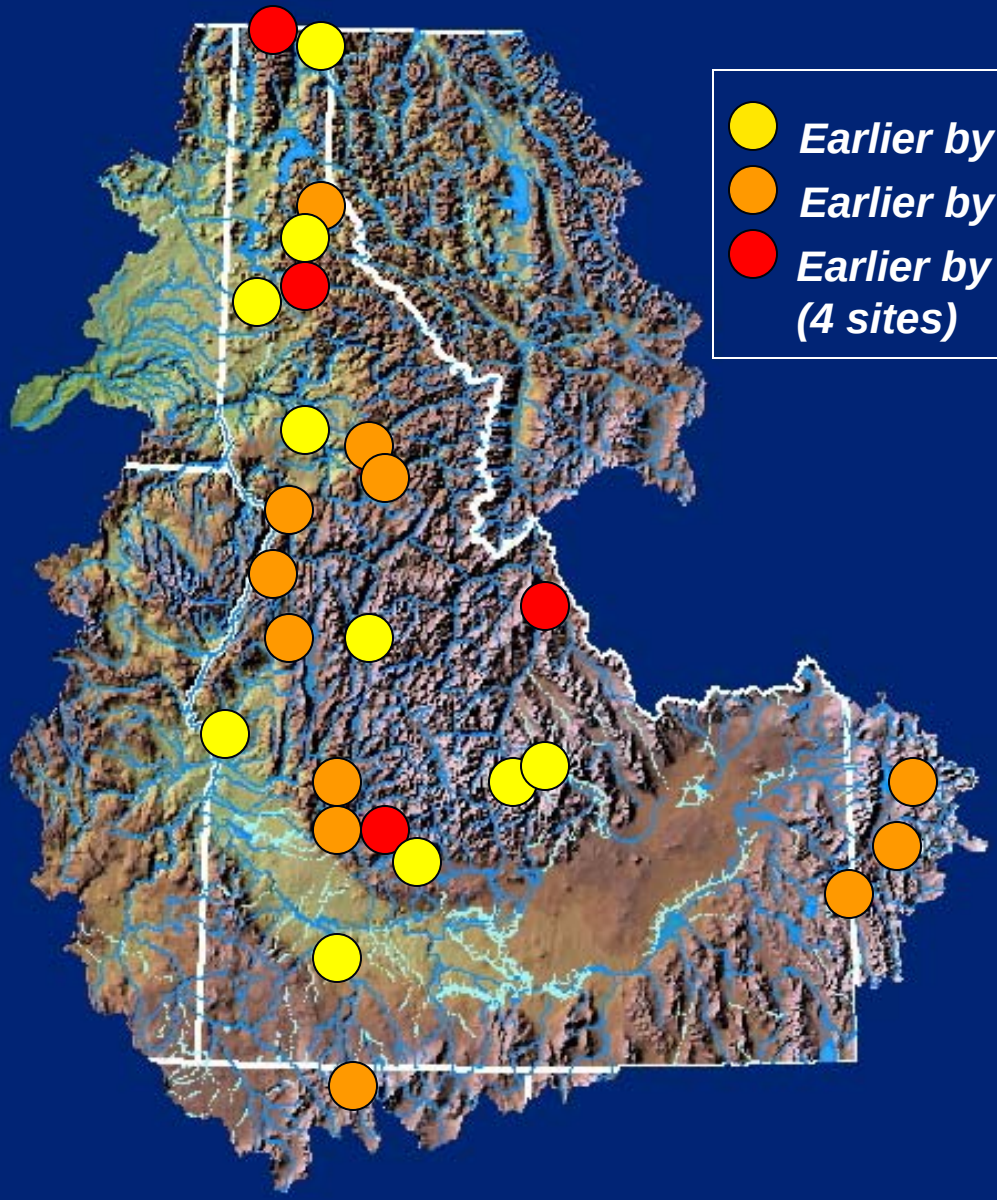


USGS science for a changing world


MEAN DAILY DISCHARGE, CFS
3,000
2,500
2,000
1,500
1,000
500
0
1954-1979
1980-2007
Jan
Feb
Mar
Apr
May
June
July
Wyoming
Jackson
Snake River Plain
Pocatello
Greys River near Alpine, WY
Period of Record -1954-2007
448 mi2
USGS
science for a changing world

First quartile of annual runoff

(Average pre versus post 1980 runoff)

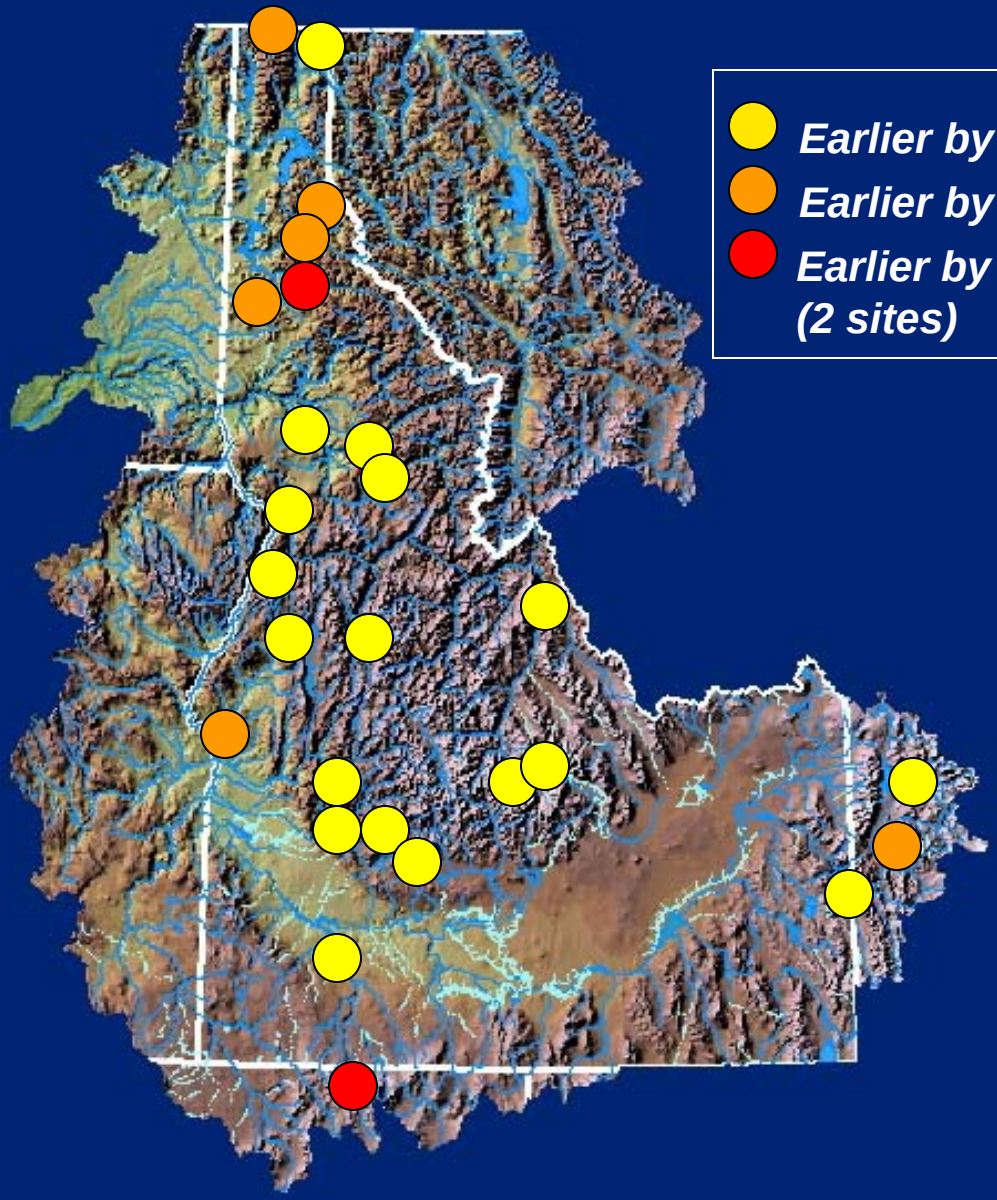


- Earlier by 0-4 days (10 sites)
- Earlier by 5-9 days (12 sites)
- Earlier by 10 days or more (4 sites)

USGS science for a changing world

Midpoint of annual runoff

(Average pre versus post 1980 runoff)



- Earlier by 0-4 days (18 sites)
- Earlier by 5-9 days (6 sites)
- Earlier by 10 days or more (2 sites)

USGS science for a changing world

Nonparametric Regional Kendall test for trend
(Helsel and Frans, 2006)

- **Adaptation of the Seasonal Kendall trend test.**
  (location substituted for season)
- **Trends are tested at each location and combined to examine for a consistent trend across entire region.**
- **Provides a direction of trend, slope with time, and p-value of significance over an entire region.**
- **Limited analysis to water years 1967–2007 to incorporate streamflow records for all 26 stations.**
- **Evaluated same runoff parameters over entire region.**

USGS science for a changing world

- Median regional changes between 1967 and 2007;
  - Annual mean stream discharge decreased by 90 CFS *(p<0.001).*
  - Annual peak stream discharge decreased by 470 CFS *(p<0.001).*
  - Annual minimum stream discharge decreased by 11 CFS *(p<0.001).*
  - Date of the midpoint of annual total stream discharge occurred 11.5 days earlier *(p<0.001).*
  - Date of the first quartile of annual total stream discharge occurred 12.5 days earlier *(p<0.001).*

USGS science for a changing world

General Summary

- ✓ **As a group, the first 7 years of this decade were some of the driest on record especially in central and southern Idaho.**
- ✓ **There is an apparent increase in the variability of runoff patterns over the last 30-40 years. These include an earlier onset of snowmelt runoff as compared to historical patterns.**
- ✓ **At a number of the stations evaluated, the earlier onset of runoff has resulted in a decrease in the annual peak streamflow and a general flattening of the annual hydrograph.**
- ✓ **Over the last 40 years across the area examined for this study, statistically significant decreases have occurred in the annual mean, annual peak, and annual minimum streamflows. Statistically significant shifts towards earlier snowmelt runoff were also found.**
- ✓ **Records from long-term gaging stations on unregulated streams are a valuable tool for examining historical changes in streamflow patterns, basin runoff characteristics, and regional climatic changes.**

USGS
science for a changing world